

# EUV Properties of Laser-Plasma using frozen Xe targets



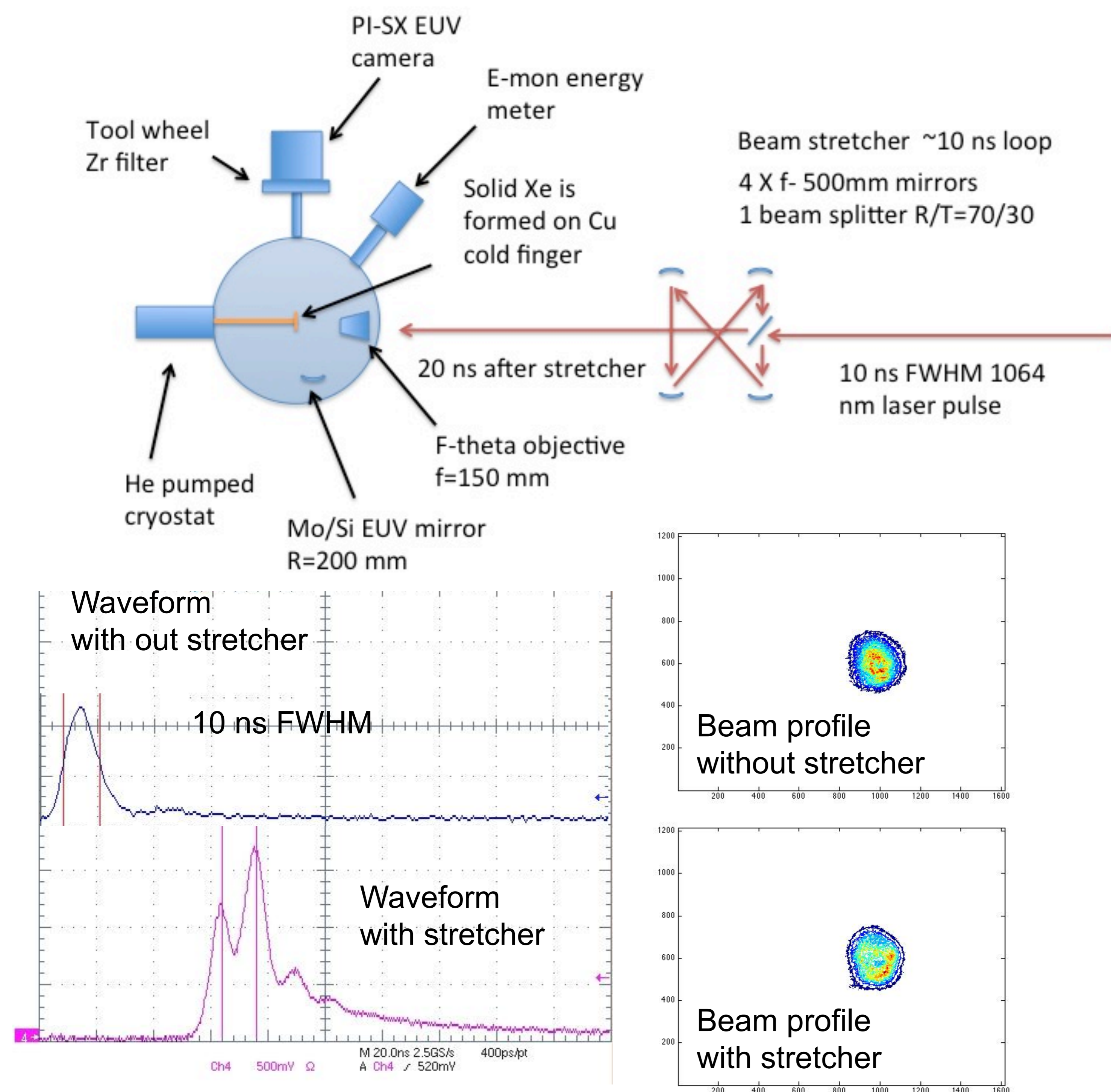
Andrew Effenberger Jr, Mark Tillack  
University of California San Diego



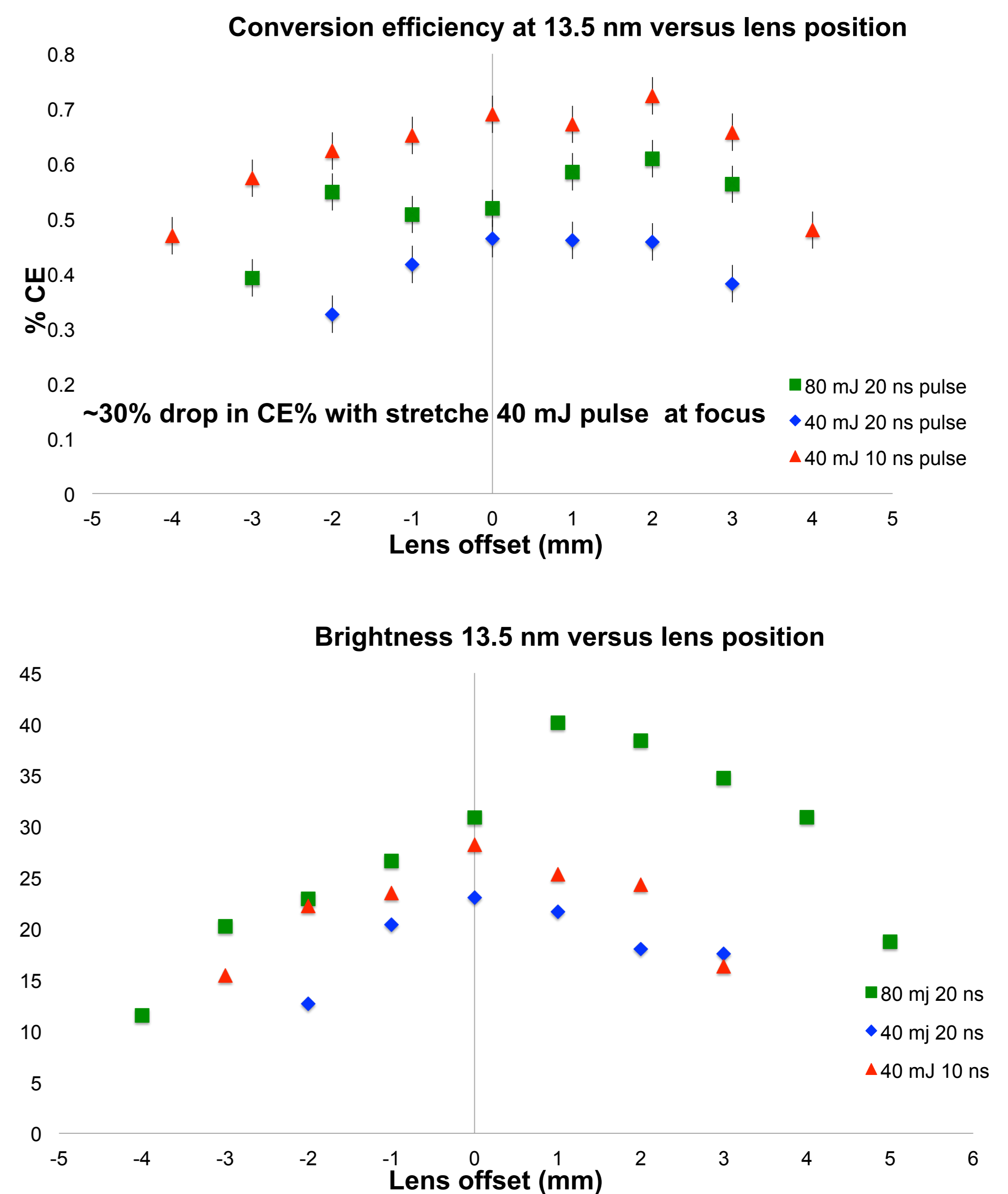
## Introduction

The use of Sn as target material for an EUV light source provides significant benefit for high power sources, because Sn provides the best conversion efficiency of and material into the bandwidth of interest to industry.<sup>1</sup> However; Sn also creates condensable debris that can contaminate optics and other nearby components.<sup>2</sup> Xe emits less in-band light, but this deficiency might be acceptable in metrology applications that do not require as much in-band power as a high-volume exposure tool. For metrology, maintaining a stationary, reproducible emitting region is more important to meet the more stringent étendue requirement. In this work, EUV properties (dominant emitting region, conversion efficiency) were studied from laser-produced plasmas using a frozen Xe target. Variables such as pulse duration and spot size were investigated.

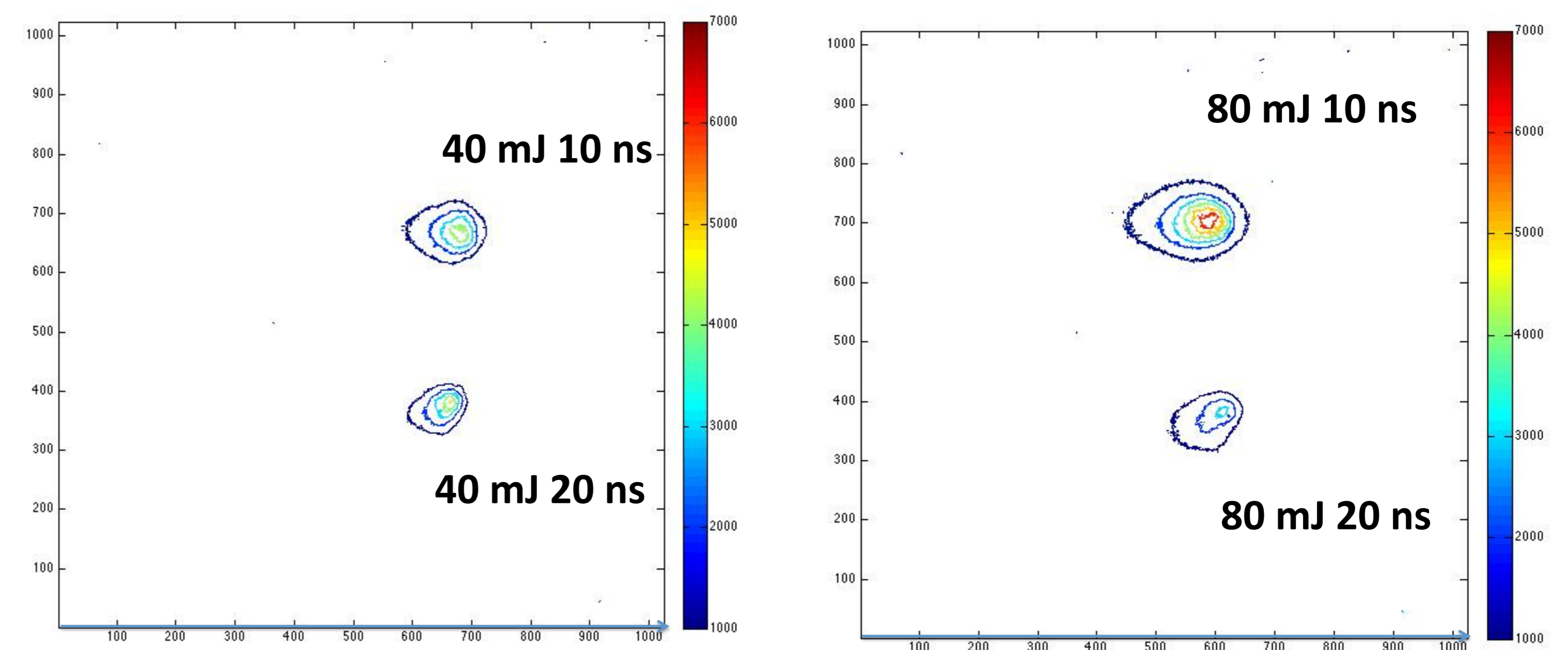
## Xenon EUV experimental set-up



## Results



DER 13.5 nm images of 10 ns pulse and stretched pulse at focus



## Conclusion

- EUV experiments were successfully conducted on Xe ice (~200 um thick) grown on the surface of a Cu cold finger at ~30 K.
- There was ~ 30% drop in %CE when comparing 10 ns FWHM pulse with the stretched pulse of 20 ns FWHM, which conflicts with results found by Tao et al. on Sn samples<sup>3</sup>
- The brightness of the DER (13.5 nm) was reduced slightly (~ 18%) when comparing a 40 mJ 10 ns pulse with the stretched 40 mJ pulse.
- Increasing the energy from 40 mJ to 80 mJ for stretched pulse resulted in a slight increase in %CE and an increase of 27% in brightness.
- EUV source size is slightly decreased with longer pulse duration which Tao et al. also observed in Sn samples<sup>3</sup>
- Future studies will include a wider range of pulse energies and time resolved interferometer of the laser generated plasma.

We are grateful for the financial support of KLA-Tencor and the guidance of KLA-Tencor staff: Oleg Khodykin, Konstantin Tsigutkin, and Dan Wack.

1. Coons, R., Compos, D., Crank, M., Harilal, S. & Hassanein, A. Comparison of EUV spectral and ion emission features from laser-produced Sn and Li plasmas. *Proceedings of the SPIE - The International Society for Optical Engineering* **7636**, 763636 (2010).  
2. Harilal, S. S. et al. Extreme-ultraviolet spectral purity and magnetic ion debris mitigation by use of low-density tin targets. *Optics Letters* **31**, 1549–1551 (2006).  
3. Tao, Y. et al. Investigation on the interaction of long duration Nd:YAG laser pulse with Sn plasma for an EUV metrology source. *Proc. SPIE - Int. Soc. Opt. Eng. (USA)* **7969**, 796930 (8 pp.)–796930 (8 pp.) (2011).